INTERNATIONAL TSUNAMI INFORMATION CENTER

NEWSLETTER

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FOURTH MEETING OF THE INTERNATIONAL COORDINATION GROUP FOR THE TSUNAMI WARNING SYSTEM IN THE PACIFIC -- Wellington, New Zealand, February 4-7, 1974

Background:

This Group was officially established in 1966 by the Intergovernmental Oceanographic Commission's Resolution (IOC/IV-Res 1) adopted at the IOC Paris meetings of November 3-12, 1965. The first meeting of the Group was held in Honolulu, Hawaii on March 25-28, 1968. Since then the Group has met every two years. The functional responsibilities of the Group have been defined by the IOC as follows: (1) effect liaison among the participating IOC Members; (2) promote exchange of information on developments of observing methods and of techniques of tsunami forecasting; (3) effect liaison with other interested organizations; and (4) provide advice on the operation of the International Tsunami Information Center. The Group is now comprised of the following Member States: Canada, Chile, China, Ecuador, France, Guatemala, Japan, Korea, New Zealand, Peru, Philippines, Thailand, USA, and USSR.

Participants:

Canada	Prof. G. L. Pickard Mr. G. C. Dohler
France	Mr. F. Raguenet
Japan	Dr. Shigeji Suyehiro (Chairman)
New Zealand	Dr. R. A. Heath Dr. A. E. Gilmour Mr. J. W. Brodie
Philippines	Major Virgilio M. David
U.S.A.	Mr. B. J. Thompson Dr. G. R. Miller Mr. R. A. Eppley
U.S.S.R.	Dr. Yuri Belyaev

Organizations:

UNESCO/IOC	Dr. G. K. Giermann
IUGG	Prof. S. L. Soloviev

Observers:

Fiji	Mr. R. N. Richmond
Mexico	Almirante Doroteo Silva Lopez
U.S.S.R.	Prof. A. Alexeev
New Zealand	Mrs. K. D. Downey

Agenda:

1. Opening of the session
2. Adoption of the agenda and election of a rapporteur
3. State of implementation of recommendations from the third session of ICG/ITSU, held in Tokyo, May 1972
4. National reports on current tsunami research and instrumental developments
5. International Tsunami Information Center's development
6. Consideration of resolutions concerning ITSU adopted by the Eighth Session of the IOC Assembly, Paris, 5-17 November 1973
7. Consideration of recommendations from the IUGG Tsunami Committee meeting held in Wellington, 29 January to 1 February 1974
8. Proposals for further expansion of the Warning System
9. Proposals for further improvements in communication including standardization of information exchange and dummy tests
10. Preparation of educational material to raise public awareness of the danger of tsunamis
11. Other matters
12. Date and place of the Fifth Session of the ICG/ITSU
13. Adoption of the Summary Report
14. Closure of the session

Summary of the Meeting:

The Session was opened by the Chairman of the Group, Dr. Suyehiro, who welcomed the participants and guests to the opening session and expressed his sincere thanks to the Government of New Zealand for its kind offer to host the meeting. On behalf of the host country, Mr. F. Turnovsky, Deputy Chairman of the New Zealand National Commission, welcomed the delegates and observers to the Victoria University of Wellington, and wished the Group a successful meeting. The representative of UNESCO and the Intergovernmental Oceanographic Commission, Dr. Giermann, then welcomed the members of the

Group, the representative of IUGG and the observers of Mexico and Fiji in the name of the Director-General of UNESCO and of the Secretary of the IOC. He expressed the wish that the two observer countries may no longer hesitate to become members of the Group, as the success of the warning system depends largely on the participation of all countries in the Pacific region.

The Chairman, Dr. Suyehiro, reviewed his report on the actions taken on the recommendations of the 3rd session. With regard to the recommendation on standardization of urgent tsunami-related information, a small ad hoc group was set up to formulate recommendations for discussion under item 9 of the agenda. Dr. Suyehiro stressed two important events which had taken place during the period between the 3rd and the 4th sessions: the 4th session of the Joint WMO/IOC Group of Experts on Telecommunications, held in Geneva, 12-19 December, 1972, and the 8th session of the IOC Assemby held at Paris, 5-17 November, 1973. He expressed his deep satisfaction with the decision taken by the Assembly to continue the Group in its existing form.

The delegates of Canada, Japan, New Zealand, Philippines, U.S.A., and U.S.S.R. presented reviews of their reports on the national activities in their respective countries. The observers of Fiji and Mexico made relevant statements. Some of the significant items from the National Reports can be summarized as follows:

> Canada announced that a new tide station for the TWS has been established at Langara Islands, a small island at the northwestern corner of the Queen Charlotte Islands, British Columbia. A comprehensive book on tsunamis, entitled, "Tsunamis - A Review" has been written by Dr. T. S. Murty of Ottawa. The book is expected to be published in 1975; Japan reported that arrangements were completed for the automatic exchange of tsunami messages between Khabarovsk, Tokyo and Honolulu through ADESS (Automatic Data Editing and Switching System) at JMA. Plans for additional seismic stations to improve the Japanese Regional Warning Centers' capability for rapid epicenter determinations were also announced; the Philippines has established a Special Committee on Tsunami Warning System to deal with tsunami matters on both local and international levels. An Emergency Broadcast System has been organized for the dissemination of warnings in the Philippines. Two new Philippine tide stations are planned for the TWS, Davao and Aparri; the U.S.A. reported on organizational changes which have affected the TWS. Four new U.S. tide stations have been added to the TWS: Canton Island, Sand Point, Alaska, Fort Point, California and San Diego, California. U.S. plans for the instrumentation of one seismic station and one tide station for satellite telemetry by July 1, 1974 were described; the U.S.S.R. reported the installation of new recording instruments for seismic stations in the warning service and an off-shore wave sensor for detecting tsunamis. An experimental seismic tripartite array was operated for determination of epicentral azimuth.

The new Director of ITIC, Mr. Robert Eppley, reported on the latest developments and activities of the Center. In discussions concerning the ITIC, a proposal was made by Canada to introduce the post of an Associate Director at ITIC, from another country than the United States, in order to make the Center more international. The IOC representative informed

the Group that funds were available to send two scientists to the Center, preferably from developing countries, for a period of about 6 weeks. The Director of the Center also agreed to be of assistance in the exchange of scientists between different regions.

The IOC representative introduced a resolution adopted by the 8th Session of the IOC Assembly which asked UNESCO and UNDP (United Nations Development Program) to provide support and assistance to the developing countries in order to enable them to set up their own national warning systems. It was suggested that the Group assist developing countries through providing an action plan for establishing a national warning system and participating in the international tsunami warning system. It was decided that the Director of ITIC will advise the Governments on sources of international funds for such purposes.

The Group discussed ways and means of how the Tsunami Warning System in the Pacific might be expanded. A list of preferred sites for the establishment of tide and seismic stations was approved by the Group.

The IOC representative informed the Group that the Secretariat is preparing a tsunami prospectus in several languages, and that it is also negotiating with the UNESCO film division on the production of a film on tsunami warning in which elements of national films might be incorporated.

The Group expressed the wish that liaison should continue to be effected with countries which are members of the Tsunami Warning System but not of the ICG. The Secretary is requested to invite those countries (such as Mexico, Fiji, Western Samoa, Papua New Guinea, etc.) to join the Group.

The Group agreed to have the next meeting in the first quarter of 1976, and asked the IOC Secretary to start negotiations about the location of the next meeting with countries in Latin America.

Recommendations * (Abridged)

No. 1. The ICG for the Tsunami Warning System in the Pacific:

Noting the Canadian proposal that it would be advantageous to the international community and to ITIC to select among the other participating Member States an Associate Director who would work in close cooperation with the U.S. Director in the operation of the Tsunami Warning System and the ITIC;

Endorses the view of the Tsunami Committee of IUGG that visits of scientists, particularly from countries whose tsunami observing and warning systems are still developing, to institutions of other countries are an effective way of improving experience and facilitating intercommunication of ideas for the better understanding of all aspects of tsunami research;

Recommends that the functions of the ITIC as outlined in the annex to this recommendation be endorsed;

Recommends further that an Associate Director of the ITIC be selected to work with the Director at the Center.

* -- These recommendations are to be considered by the 4th Session of the Executive Council of the Intergovernmental Oceanographic Commission, Ottawa, June 1974.

Annex to Recommendation 1 - ITIC Functions

To give technical advice on the equipment required for an effective warning system and to provide assistance in the establishment of national warning systems. Periodic study and assessment visits should be made to developing countries in order to evaluate their instrumentation requirements, assess their performance, offer advice as appropriate, and suggest avenues for assistance.

To evaluate the performance of the Tsunami Warning System with regard to communications, data networks, the Warning Center, and dissemination.

To coordinate the development of an observing system which will provide the information necessary for the issuance of effective tsunami warning to those nations wishing to receive such messages.

To maintain a tsunami data acquisition, storage, and retrieval system.

To encourage a visiting scientist program by providing facilities at ITIC and arranging for exchange of scientific personnel among countries.

To publish a Newsletter on a regular basis and distribute it to interested individuals and institutions.

To publish an disseminate appropriate compilations of tsunami information or data. Such publications may include regional tsunami catalogs and yearly summaries of tsunamis.

To maintain a library of publications related to tsunamis.

No. 2. The ICG for the Tsunami Warning System in the Pacific:

Recognizing that additional seismograph and tide stations are needed to provide better geographical coverage for earlier detection of tsunamis, including their magnitude and propagation rates and more accurate epicenter determinations;

Having considered the lists of seismograph and tide stations submitted by the ITIC and Member States;

Provides the priority lists of seismograph and tide stations contained in the Annex to this recommendation for consideration for establishment by Member States;

Requests the Secretariat to transmit these lists of stations to the appropriate Member States inviting them to establish such stations as part of the Tsunami Warning System and to indicate if technical and, in the case of developing countries, financial assistance would be required to do so;

Desiring to clarify the role of each station in the Tsunami Warning System from an international point of view;

Recommends that the four categories listed in the Annex to this recommendation be adopted for use within the Tsunami Warning System;

Requests Member States to inform the Director of ITIC how each of their existing or future (including those proposed in the Annex to this recommendation) stations should be categorized.

Annex to Recommendation 2 - Proposed Tide and Seismograph Stations for the TWS

Tide Stations - First Priority

Amchitka, Alaska
Salina Cruz, Mexico
La Libertad, Ecuador
Aparri, Philippines
Iwo Jima, Volcano Is.
Iturup, Kuril Is.
Petropavlovsk, Kamchatka
Christmas Island
Socorro Island
Guadalupe Island

Tide Stations - Second Priority

Trinity Is. (Sitkinak I.), Alaska
Yakataga, Alaska
Puntarenas, Costa Rica
Buenaventura, Colombia
Talara, Peru
Chimbote, Peru
La Serena, Chile
Onekotan, Kuril Is.
Komandorski Is., U.S.S.R.
Pitcairn Island

Seismograph Stations - First Priority

Tacubaya, Mexico
Antofagasta, Chile
Petropavlovsk, Kamchatka

Seismograph Stations - Second Priority

Galapagos Is.
Sombrero, Chile
Minamitorishima
Port Moresby, Papua New Guinea

Categories of Stations of the Tsunami Warning System

1. Stations which automatically report data in real time, utilizing existing or future communication systems. The station can be interrogated either nationally or internationally.

2. The same as above with the exception that interrogation is only possible within the national network.

3. Stations which require observers to transmit data or messages.

4. Stations which are operated only during expected tsunami activity.

No. 3. The ICG for the Tsunami Warning System in the Pacific:

Recognizing that internationally agreed upon wave reporting procedures are required;
Having considered the "Wave Reporting Procedures for Tide Observers in the Tsunami Warning System" issued by the U. S. Department of Commerce (Publication 30-3, revised June 1970), and comments made by Member States;
Desiring to clarify the reporting procedures for tsunami waves;
Recommends that Sections 4, 5, 6 and 7 of U.S. Department of Commerce Publication 30-3, revised June 1970, be adopted for international use;
Requests the Secretary to arrange that these sections be issued as a special document in the working languages of the Commission, and to make it available to all Member States.

Copies of the complete Summary Report for the meeting will be available from the Secretary, IOC, Unesco, Paris.

NEW TWS TIDE STATION AT LANGARA ISLAND

At the Wellington meeting of the ICG, the Canadian delegation reported on the successful installation of a gauging station at Langara Island. The following description of the installation was extracted from the Canadian National Report:

> Langara Island is located at the northwestern corner of the Queen Charlotte Islands, British Columbia, at Latitude 54° 15'N, Longitude 133° 02'W. The only means of transportation from the island to the mainland, about one hundred miles, exists by government operated or chartered aircraft or ship. A lighthouse is located at Langara Island, however, a watch around the clock is not maintained. Unfavorable weather conditions which occur quite frequently, make it often impossible to visit the island. For these reasons, and several others, a type of installation was required which could be called unique in the tsunami warning network.
>
> Water levels had to be measured by a sensor carried 1.5 miles over land line, then transmitted 110 miles as the crow flies to the mainland and again carried twenty miles by land line where the data is recorded.
>
> The placing of a sensor in a 2.5 ton concrete block at a depth of more than twenty feet at low tide and at about 250 feet from the water's edge proved to be in vain. The cable connection between transmitter and sensor was severed several times and finally the 2.5 ton concrete block disappeared.
>
> A last and final attempt was made utilizing the 151 foot, 1.5 inch diameter, diamond drilled hole which was required previously for the transducer cable and to be utilized at this time in conjunction with a bubbler system. This suggestion proved successful and since June, 1973, excellent data are obtained from Langara Island.

COMMUNICATION PLAN TO BE REVISED

A new edition of the Communication Plan for the Tsunami Warning System is now being prepared which will incorporate the many changes which have occurred since the publication of the Seventh Edition. All TWS participants are urged to examine their copy of the Plan, particularly with regard to information concerning their station or organization and report any changes to Director, Tsunami Warning Center, 91-270 Ft. Weaver Road, Ewa Beach, Hawaii 96706.

TSUNAMIS IN 1973

Only moderate tsunami activity was observed during the year, 1973. There were no fatalities and only a minor amount of damage was attributed to tsunamis. Three of the five tsunamis during the year were generated in the Japan-Kuril region. The others resulted from earthquakes in Chile and Mexico.

Following is a summary of tsunami observations and associated earthquake data. The seismic information has been obtained from publications of the National Earthquake Information Service, U. S. Geological Survey. The tsunami heights are crest to trough.

Earthquake Data	Tsunami Data	
January 30, 1973 H= 21-01-12.5 U.T. 18.5N, 103.0W Depth= 43 km., Magnitude= 7.5 Near coast of Michoacan, Mexico 52 reported dead from earthquake. Heavy damage in States of Colima, Jalisco, and Michoacan.	Pago Pago, American Samoa Hilo, Hawaii Kahului, Hawaii Minor tsunami of about 1 meter amplitude reported in Mexico. No damage from tsunami.	22 cm. 22 cm. 24 cm.
February 28, 1973 H= 06-37-49.5 U.T. 50.5N, 156.6E Depth= 27 km., Magnitude= 7.2 Kuril Islands	Attu, Aleutian Islands	30 cm.
June 17, 1973 H= 03-55-02.9 U.T. 43.2N, 145.8E Depth= 48 km., Magnitude= 7.7 Hokkaido, Japan region Earthquake and tsunami caused more than $5 million damage and injured 23 persons. Most of damage and injured were on Hokkaido.	Nemuro Japan Kushiro, Japan Hachinohe, Japan Urakawa, Japan Iturup, USSR (Kasatka Bay) Iturup, USSR (Whale Bay) Kunashir, USSR JMA issued minor tsunami warning for Pacific coasts of Hokkaido and Tonoku. USSR issued tsunami warning. Watch issued by Pacific Tsunami Warning Center.	303 cm. 95 cm. 96 cm. 101 cm. 61 cm. 36 cm. 20 cm.
June 24, 1973 H= 02-43-25.5 U.T. 43.3N, 146.4E Depth= 50 km., Magnitude= 7.1 Kuril Islands	Hanasaki, Japan Kushiro, Japan Hachinohe, Japan East. Hokkaido, Japan JMA issued minor tsunami warning for Pacific coast of Hokkaido. USSR issued tsunami warning.	104 cm. 20 cm. 9 cm. 122 cm. (max.)
October 5, 1973 H= 05-45-27.3 U.T. 33.0S, 71.9W Depth= 14 km., Magnitude= 6.5 Near coast of central Chile	Valparaiso, Chile	40 cm.

The Director, ITIC would appreciate receiving any additional reports of tsunami activity during 1973.

IUGG TSUNAMI SYMPOSIUM

Tsunami scientists from five countries met in Wellington, New Zealand from January 29 to February 1, 1974 for a meeting of the International Union of Geodesy and Geophysics Tsunami Committee and Symposium. The Committee has as its principal objective, the promotion of tsunami research towards the improvement of the Tsunami Warning System. At its meeting on February 1, the Tsunami Committee adopted the following recommendations and resolutions:

Committee Recommendations -- The IUGG Tsunami Committee recommended to the International Coordination Group for the Tsunami Warning System:

1. That bottom mounted tide gages should be installed in the deep ocean to provide information to increase our knowledge of tsunami behavior and to permit improved prediction techniques.

2. That simple land-based instruments be installed to ensure records of tsunamis, such instruments being designed to have adequate range for water levels for likely tsunamis and with recording components located above the reach of tsunamis or able to continue recording even if inundated.

3. That microbarograph and ionospheric sounding data be collected in association with tide or tsunami gage and seismograph records for tsunamis to permit further investigation of the practicality of using atmospheric motions resulting from surface motions to provide additional information for the TWS.

4. Recognizing that numerical methods are now at the stage in which it would be possible to provide useful wave time histories on an ocean-wide basis in the Pacific and that calculations for a modest number of potential sources (about 15) would provide sufficient information to permit local effect calculations anywhere in the Pacific, that such calculations be made, including the selection of representative sources, calculations of normalized height wave histories over the entire Pacific, numerical evaluation of response factors for key tide stations for rapid normalization of oceanic propagation codes, and provision of standardized local shelf and harbour oscillation codes to member countries to be used for calculation of local effects, particularly flooding.

5. That the use of commercial satellite communication facilities be considered for the TWS until government operated satellites are available or as well as these.

6. That, where pertinent, existing warning systems be expanded to include the natural hazard of tsunamis.

7. That the visits of tsunami scientists, particularly from countries whose tsunami observing and warning systems are still developing, to other institutions should continue to be encouraged as a very effective means for improving experience and facilitating intercommunication of ideas for the better understanding of all aspects of tsunami research.

(The International Coordination Group for the TWS met the following week and endorsed recommendations 1 through 4. The Group considered the other recommendations during discussions under relevant agenda topics.)

Committee Resolutions --

1. It was resolved that the "Catalog of Pacific Tsunamis" prepared by D. Cox (U.S.A.), K. Iida (Japan) and S. L. Soloviev (U.S.S.R.) should be published and the Committee recommends that IUGG seek ways and means to publish the Catalog.

2. It was resolved that, considering the importance of the ITIC for tsunami research, the attention of the Intergovernmental Oceanographic Commission should be drawn to the need for ITIC to be adequately staffed, in particular so that it may be able to collect marigrams, associated seismograms and relevant descriptive data and observations.

3. It was resolved that the attention of ICG/ITSU be drawn to the fact that the Royal Society of New Zealand has offered to arrange for the publication of the Papers presented at the Wellington Tsunami Symposium and that early publication would be facilitated if financial support could be secured through external sources such as IOC.

Symposium Abstracts --

Thirty nine papers were presented at the Symposium covering Tsunami Generation, Instrumentation and Experiments, Tsunami Propagation, and Tsunami Run-up. Abstracts of several representative papers from each session have been selected for inclusion in this Newsletter.

A B S T R A C T S

KINJIRO KAJIURA, Earthquake Research Institute, University of Tokyo.

Source Mechanism of Earthquake and Tsunami Generation. Recent studies made in the Earthquake Research Institute related to the tsunami generation are reviewed. Major topics are: 1) the detailed study of the mechanism of major earthquakes and the statical deformation of the sea bottom based on the fault plane model, 2) a trial to estimate the characteristics of the bottom deformation at the tsunami source from tsunami data obtained along the coast. Comparison of source parameters of tsunami estimated from seismological data and from tsunami data indicates good correspondence in ordinary earthquakes and provides a physical basis for the already known statistical relationships between earthquake and tsunami. The large deviation from these statistical relationships may indicate the unelastic nature of the crustal deformation accompanying the earthquake. Furthermore, the characteristics of an unusual earthquake -- Tsunami Earthquake after Kanamori -- is found, the magnitude of this earthquake is relatively small but the generated tsunami is very large. The information of tsunami source may be used with advantage in the prediction of earthquake in conjunction with the geodetic and other data.

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KATSUYUKI ABE, Department of Geophysics, Faculty of Science, Hokkaido University, Sapporo 060, Japan.

Tsunami and Earthquake Faulting. The relation between tsunamis and sea-bottom deformations associated with great earthquakes is studied on the basis of a fairly complete set of seismological and tsunami data. The seismic results are included in the calculation of static crustal deformations. The calculated deformations are compared with the tsunami source area as obtained by the inverse refraction diagram, the first motion of tsunami waves, and the height of the sea-level disturbance at the source. It is found that such deformations as predicted by the seismic results can quantitatively explain the source parameters of tsunamis. These findings strongly favor the idea that tsunamis are

generated by tectonic deformations rather than by submarine landslides and slumps. A precise determination of the tsunami source parameters provides a valuable method for estimating the extent of faulting in submarine earthquakes.

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A.S. ALEKSEYEV and V. K. GUSJAKOV, Computer Center, Siberian Branch of Academy of Sciences, Novorsibirsk, USSR.

Numerical Modelling of Tsunami and Seismic Surface Waves Generation by a Submarine Earthquake. In the work the generation of gravity and elastic waves in a layer of the homogeneous compressible gravitating liquid overlaying the homogeneous elastic halfspace is examined. The model source, having some properties of a real source of an earthquake locates within the elastic halfspace. The exact mathematical solution of the problem is found and there are calculated the dispersion curves of a phase and group velocity, amplitude spectra and theoretical seismograms for displacements in a gravity, hydroacoustic and seismic surface waves. The physical and numerical analysis is carried out for the condition of tsunami generation depending on the depth and dimensions of the source, direction of the fault and the rupture-velocity. It is shown that under definite combinations of source parameters the earthquakes become most tsunami-dangerous. The possibility of using of the hydroacoustic and seismic surface waves for tsunami prognosis is evaluated.

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JOSEPH L. HAMMACK, JR., Research Fellow in Civil Engineering, W. M. Keck Laboratory of Hydraulics and Water Resources, California Institute of Technology, Pasadena, California 91109.

Tsunamis in a Stratified Ocean. The surface and internal wave systems generated in a density-stratified fluid domain by a deformation of the bounding solid boundary are investigated both theoretically and experimentally. The fluid domain is assumed to be two-dimensional with a uniform depth and infinite lateral extent. The modeled variation of density with depth consists of two layers of different but constant density (gravitationally stable) separated by a thin interfacial region where large density gradients occur. Results are presented for a specific deformation of the bed consisting of a block section which displaces vertically either up or down according to a prescribed time-displacement history.

Theoretical computations for the internal and surface waves are based on a linearized description of wave behavior for the limiting case of an abrupt change in density at the interface, i.e., the interfacial thickness is neglected resulting in only a two layer system. Experiments have been conducted in a laboratory wave tank equipped at one extremity with a bottom wave generator which consists of a moveable bed section whose time-displacement history is controlled by an electro-hydraulic-servo system. A technique has been developed which permits the entire wave tank to be stratified as a two layer system whose depths can be varied; the thickness of the interfacial region can be minimized initially to approximately 1 cm. The surface waves and density profiles are measured along the tank during each experiment. The waves propagating along the interface are also measured using a unique gage developed especially for this purpose which consists of a laser-optics-detector system.

Results indicate that two distinct internal wave systems result from the bed deformations. One system is induced by a coupling of the surface waves with the interface; these internal waves propagate at the same velocity as the surface waves and have an amplitude distribution related directly to the surface waves. A second internal wave system is generated by the motion of the interface in the generation region which results from the bed deformation; these waves travel at a much slower velocity than the primary surface waves and are quickly left behind by this system. The coupling of the surface and internal waves for various layer depths is investigated as well as the applicability of the simplified theoretical model for describing the wave behavior. Special attention is also given to the effects of the density stratification on the primary surface waves by comparing these experiments with similar experiments without a density stratification.

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KENNETH H. OLSEN, Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico 87544

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JAMES E. MCNEIL, Sea Operations Department, Delco Electronics, Goleta, California 93017

For IUGG Tsunami Symposium, Wellington, New Zealand, Tsunami Recording Instrumentation at Three Small Atolls in the Mid-Pacific. Records of tsunamis obtained at coastal tide gauge stations can be greatly affected by complex nearshore interactions such as refraction, shelf and bay resonances and nonlinear runup effects. Pending installation of more ideal deep ocean-bottom instrumentation, relatively uncontaminated records of the deep-sea, mid-ocean characteristics of tsunamis can be obtained by high sensitivity transducers placed outside the reef at small, steep-sided atolls. We have installed such instrumentation at Wake Island, Marcus Island, and Johnston Atoll in the mid-Pacific Ocean. These stations have been continuously operated since January 1972, June 1972 and September 1973, respectively.

Instrumentation consists of pressure and water temperature transducers installed outside the reefs in water depths ranging from 17 to 300 meters. The frequency modulated signals are transmitted to shore via underwater cable where they are digitally counted and recorded on computer compatible magnetic tape. A digital time series of barometric pressure is also obtained as well as a real time paper chart display of sea level variations. The data band pass is in the period range between ten seconds and one week. For the digital ocean level records, least count sensitivities at all stations are less than one millimeter of water level.

Since these mid-ocean stations were installed, reported tsunamis in the Pacific basin have been too small or too distant and localized to be detectable on our records. The performance of the equipment is compared and illustrated by time records and power spectra of ambient conditions between 26 September and 5 October 1973.

S. L. SOLOVIEV, G. N. KHRISTOFOROV, and V.M. JACQUES, Sakhalin Complex Scientific Research Institute Academy of Sciences, USSR.

Bottom Hydrophysical Observations Near Shikotan Island. In autumn 1973 three bottom hydrophysical installations are put into operation in 15 km from Shikotan Island. The average distance between installations is equal 5 km.

Hydrostatic pressure, i.e., water height, temperature and velocity of near-bottom currents are measured in sequence every 10 sec. In addition a bottom seismograph is installed. Obtained records show that local conditions influence yet on long-period processes. Tide heights on shelf are somewhat greater that in Malokurkiskaya bay. Near bottom currents are partly turbulent. Daily changes of near-bottom temperatures reach 3-5°. All hydrophysical fields change during the typhoon.

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WILLIAM G. VAN DORN, Scripps Institution of Oceanography, University of California, San Diego.

Advance Prediction of Tsunamis and Tsunami Effects. A combination of three recent, and relatively independent, research developments may soon make possible the advance prediction of tsunami characteristics at any shoreline location, as well as the quantification of real-time warnings, given early source or wave information. These are:

(1) The demonstrated capability of making deterministic local predictions of wave motions anywhere in the ocean from known source motions.

(2) The identification of potential sources (fault blocks) from seismic aftershock patterns and tectonic evidence, so that advance predictions can be made for hypothetical tsunamis originating from all such sources, assuming unit normal displacements.

(3) Studies of recurrence intervals for great earthquakes suggests that they are not random, but, instead, are spatially and temporally ordered by the orientations and rates of strain accumulation of large fault blocks. Thus, there is some geophysical basis for computing expectancies of major tsunamis.

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S. S. VOYT and B. I. SEBEKIN, Institute of Oceanology, Moscow, U.S.S.R.

Long Wave Intensification Due to the Influence of Bottom Topography. The problem investigated is the increase in amplitude of waves travelling from the open ocean over the continental slope into a shelf. The basin considered has a cylindrical bottom profile and is assumed to rotate with uniform angular velocity. The deep and shallow parts of the basin are both semi-infinite and of constant depth. The transitional area which models the continental slope is represented by an arbitrary continuous monotonic function. In order to consider energy dissipation, it is assumed that there is no reflected wave. Within the framework of linear long wave theory, an algorithm is presented for calculation of the amplification of the transmitted wave, amplification resulting from the passage of the wave over the region of variable depth. Numerical results wave obtained for a concrete example.

The maximum amplification ratio of the incoming wave amplitude has been evaluated analytically for an arbitrary monotonic profile in the transitional area. This maximum amplification ratio wave evaluated for incoming waves of frequencies higher than the inertial frequency and under the assumption that non-linear effects do not occur in the shallow shelf region.

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HAROLD G. LOOMIS, Joint Tsunami Research Effort, National Oceanic and Atmospheric Administration, Honolulu, Hawaii.

Progress in Numerical Methods for the Tsunami Problem at JTRE, Honolulu, Hawaii. Considerable progress has been made in the numerical treatment of various aspects of the tsunami problem at the Joint Tsunami Research Effort of NOAA located at the University of Hawaii. A package computer program has been written to solve a large class of harbor resonance problems and is used routinely for various bays and harbors of variable water depth and geometry. The bathymetry of the water region is supplied (with zeros at land areas) from which the linear eigenvalue problem is solved for normal modes. The boundary conditions for the closed boundaries are automatically provided for in the program. The open boundary must be specified as a node.

A second package program provides for time-stepping a wave of any prescribed shape and angle of arrival into a coastal region. From the bathymetry of the region, the program constructs a code satisfying the closed boundary conditions. The basic long wave hydrodynamic equations with friction and advection terms are used in this program.

A third major effort has gone towards a satisfactory treatment of an open boundary of a region that is to be treated as transparent to wave energy. The outgoing wave in the region is extrapolated to a row of external grid points using the direction of the wave particle velocities for direction and the local celerity to transmit the wave across the boundary with minimal reflections. The package program mentioned above was adapted to spherical coordinates with the transparent boundary condition to simulate a tsunami in a section of the North Pacific Ocean.

The marker and cell program from Los Alamos was modified for use in a situation where the fluid cells have very long horizontal extent as compared to the vertical dimension of the cell. Calculations were done on regions with sloping beaches and with the underwater barriers. One vertical and one horizontal dimension was used. The program includes the complications of changing fluid boundaries due to the motion of the wave and water overflowing the beach.

Work is in progress on the interaction of a tsunami with the Hawaiian Islands. A rectangular segment of the ocean is treated with the boundaries transparent to radiated energy from the islands. One of the interesting features of this work is that the regular bathymetric grid is calculated from recorded soundings by a sophisticated spline-interpolation scheme. This permits the grid to be rotated and recalculated so that the grid boundary is always normal to the incident wave whatever its angle of arrival. This facilitates the separation of the incident and reflected waves so that the transparent boundary condition can be affected.

T. S. MURTY and S. O. WIGEN, Marine Sciences Directorate, Department of the Environment, Canada.

Tsunami Behaviour on the Atlantic Coast of Canada and Some Similarities to the Peru Coast. Contrary to popular belief, the Atlantic Coast of Canada has been subject to tsunamis and indeed the only tsunami in the recorded history of Canada that caused numerous deaths occurred on the Atlantic Coast of Canada on November 18, 1929. Seismic considerations show that, although less frequent, earthquakes and tsunamis could occur in this region and that the tsunami-genic earthquake of 1929 is not a freak incident. This tsunami has been studied here in various aspects: propagation, resonance in bays, and secondary undulations. Power spectral studies of past tsunami data indicated several similarities with those on the Pacific Coast of Peru. Based on the similarities deduced from the so-called Nakano diagram it is proposed that, instead of studying several bays, one or two could be selected and studied in detail through a variable spacing grid to take into account both wider as well as narrower regions. This was achieved through the use of the so-called stretched coordinate system.

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A. W. GARCIA and J. R. HOUSTON, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, USA.

Tsunami Runup Predictions for Southern California Coastal Communities, USA. Predictions are made for the maximum runup resulting from tsunamis of distant origin for periods or occurrence of 100 and 500 years for several coastal communities in southern California. Tsunami source regions in both northern and southern hemispheres are considered. Statistical effects of the astronomical tide are taken into consideration in prediction of tsunami runup.

Historical evidence is used to delineate known tsunamigenic geographical regions which produce significant runup along the coastal reaches of interest. Numerical simulation of the generation and propagation of numerous tsunamis uses a hypothetical and reproducible ground displacement distributed along these known tsunamigenic regions to calculate the effects of distance and directionality. Analytical techniques are used to propagate the wave over the shoaling region representing the continental shelf. The finite element method is used to obtain estimates of the periods of the resonant modes of oscillation at those locations where historical evidence has indicated that resonance significantly amplifies the local wave amplitude. Comparisons are presented showing good agreement of data recorded at tide gauges along the west coast of the United States during the tsunami generated by the 1964 Alaska earthquake with predicted results of the simulation of this tsunami.

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S. L. SOLOVIEV, A. V. NEKRASOV, V. G. BUKHTEEV, and P. B. PYASKOVSKY, Sakhalin Complex Scientific Research Institute, Academy of Sciences, USSR, Leningrad Hydrometeorological Institute.

Materials for Tsunami Zoning of the Kurile-Kamchatka Coast. The sources of strong Kurile-Kamchatka tsunamis stretch along the Soviet Pacific Coast.

Water uplift is the greater, the longer the source is, because of smaller scattering of wave fronts. The possibility of tsunami occurrence is nearly equal along the arc.

The calculations were carried out for linear source, stretching along the arc at a distance of 70 km off it. Rays were drawn through 10 miles, being orthogonal to the source. Within each ray tube water elevation was calculated by numerical integration of non-linear one-dimensional equations of shallow water. Elevation within the source was taken in the form of halfsinusoid. The waves were calculated up to depth of 10 m. Here and at the walls of ray tubes the conditions of complete wave reflection was adopted. For back contour of the source the condition of free going off was adopted. The coast zoning according to amplitudes and periods of tsunamis was effectuated. It is shown that calculations according to Green's formula over-estimate water uplift on coast and give its erroneous distribution along it. It was studied how remoteness, width and orientation of the source influence the form water elevation near the coast.

For Kamchatka bay two-dimensional integration of linear equations of shallow water was fulfilled allowing to study the edge wave formation and propagation.

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SHIGEHISA NAKAMURA, Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan

Shock Pressure of Tsunami Surge on a Wall. This study treats a problem to estimate exact shock pressure of tsunami surge in a form of hydraulic bore on a wall, in order to give a criterion in construction of the wall and the gate at river mouth and at coast. The study has referred to an assumption of similarity between a bore caused by a dam-breaking and a surging tsunami on a river mouth or a beach.

At first, dynamical characteristics of the bore front is studied experimentally to compare with the theoretical results shown by Ritter, Dressler and Whitham. A recent work by Cross shows that the tip profile of surge is expressed theoretically by a curve of parabola with an axis corresponding to the horizontal flat bed under influence of bottom friction, which has been compared to the experimental result obtained by the author. The result suggests that the important factors in the study are velocity of the bore tip, friction at the bed and scale of the bore source or tsunami surge.

The characteristics of the bore reflected at a wall are studied referring to Stoker's theory, and the result suggests that it is preferable to reflect the tsunami inundation at a location as far as possible from the coast. When one tries to reflect the tsunami surge on beach or on a dry bed, the height of the reflected bore becomes very large to give enormous disaster on the coast. And we have to consider the countermeasure with the consideration of the reflection of the bore and problems in practice.

Cross had applied Cumberbatch's theory on shock pressure on a vertical wall by a wedge of water mass. The author has traced his application to refine Cross-Cumberbatch's theory in estimation of the shock pressure, and to find that the shock pressure depends intensively on the profile of the bore front or on the slope of the wedge of the water mass moving toward the wall.

DIGITIZED TSUNAMI RECORDS

At the recent IUGG meeting in New Zealand, researchers were encouraged to make available digitized tsunami records. The Joint Tsunami Research Effort has a small collection which is being turned over to the International Tsunami Information Center. The accompanying table gives the recording location and the dates. Some of the records do not start at the time of the first arrival of the waves. In most cases this is because the first wave washed out the tide gage. Other digitized records would be very much appreciated; if you can supply data decks please send them to the ITIC.

Recording Station	Date
One-Minute Sampling Rate	
Hilo, Hawaii	4 November 1927
La Jolla, Calif.	4 March 1952
Hilo, Hawaii	3 October 1931
San Clemente Island, Calif.	23 May 1960
La Jolla, Calif.	2 March 1933
Santa Monica, Calif.	2 March 1933
La Jolla, Calif.	9 March 1957
Honolulu, Hawaii	4 November 1952
Santa Monica, Calif.	4 November 1952
La Jolla, Calif.	4 November 1952
Oceanside, Calif.	4 November 1952
Honolulu, Hawaii	28 March 1964
Two-Minute Sampling Rate	
Wake Island	13 October 1963
Wake Island	19 October 1963
Wake Island	14 October 1963
Wake Island	21 October 1963
Midway Island	13 October 1963
Midway Island	19 October 1963
Nawiliwili (Kauai), Hawaii	13 October 1963
Maunalua Bay (Oahu), Hawaii	6 February 1966
Honolulu, Hawaii	20 December 1946
Midway Island storm	4 April 1966
Hilo, Hawaii	24 May 1960
Honolulu, Hawaii	9 March 1957
Honolulu, Hawaii	23 May 1960
Hilo, Hawaii	4 November 1952
Hilo, Hawaii	9 March 1957
Honolulu, Hawaii	4 November 1952
Waiakea, Hawaii	13 October 1963
Haleiwa (Oahu), Hawaii	13 October 1963
Hilo, Hawaii	19 October 1963
Hilo, Hawaii	13 October 1963
Honolulu, Hawaii	13 October 1963
Honolulu, Hawaii	19 October 1963

Recording Station	Date
Two-Minute Sampling Rate	
Ala Wai (Oahu), Hawaii	28 March 1964
Unalaska, Alaska	28 March 1964
Massacre Bay, Alaska	28 March 1964
Mokuole,(Oahu), Hawaii	27 March 1964
Hilo, Hawaii	27 March 1964
Honolulu, Hawaii	27 March 1964
Kahului (Maui), Hawaii	27 March 1964
Midway Island	27 March 1964
Kwajalein Island	28 March 1964
Pago Pago, American Samoa	28 March 1964

TSUNAMI INVESTIGATIONS -- January-March 1974

During the first three months of 1974, the Tsunami Warning Center at Honolulu Observatory investigated a number of possible tsunamigenic earthquakes which are listed below. Not included in this list are several lower magnitude or deep focus earthquakes which did not pose a possible tsunami threat.

Date and Origin Time (U.T.)	Epicenter	Depth	Magnitude	Region	Comments
Jan. 2, 1974 10-42-29.9	22.5S 68.4W	105 km	6.8	Northern Chile	No evidence of tsunami
Jan. 10, 1974 08-51-13.3	14.4S 166.9E	34 km	7.2	New Hebrides Is.	No evidence of tsunami
Jan. 31, 1974 23-30-05.3	7.5S 155.9E	34 km	7.0	Solomon Islands	No Pacific-wide tsunami
Feb. 1, 1974 03-12-33.1	7.4S 155.6E	40 km	7.1	Solomon Islands	No Pacific-wide tsunami

NEWSLETTER PUBLICATION INFORMATION

Although this Newsletter is intended to be a quarterly publication, the number of issues published has varied each year. For the information of those individuals and organizations who maintain a file of the Newsletter, the following listing shows the number and date of all prior issues published.

Volume I, Number 1 -- June 5, 1968
Volume I, Number 2 -- September 5, 1968
Volume II, Number 1 -- January 12, 1969
Volume II, Number 2 -- April 5, 1969
Volume II, Number 3 -- July 5, 1969
Volume II, Number 4 -- October 5, 1969
Volume III, Number 1 -- April 1, 1970
Volume III, Number 2 -- June 25, 1970
Volume III, Number 3 -- September 30, 1970
Volume IV, Number 1 -- March 15, 1971
(No Volume or Number) -- June 15, 1972; September 15, 1972; November 1973

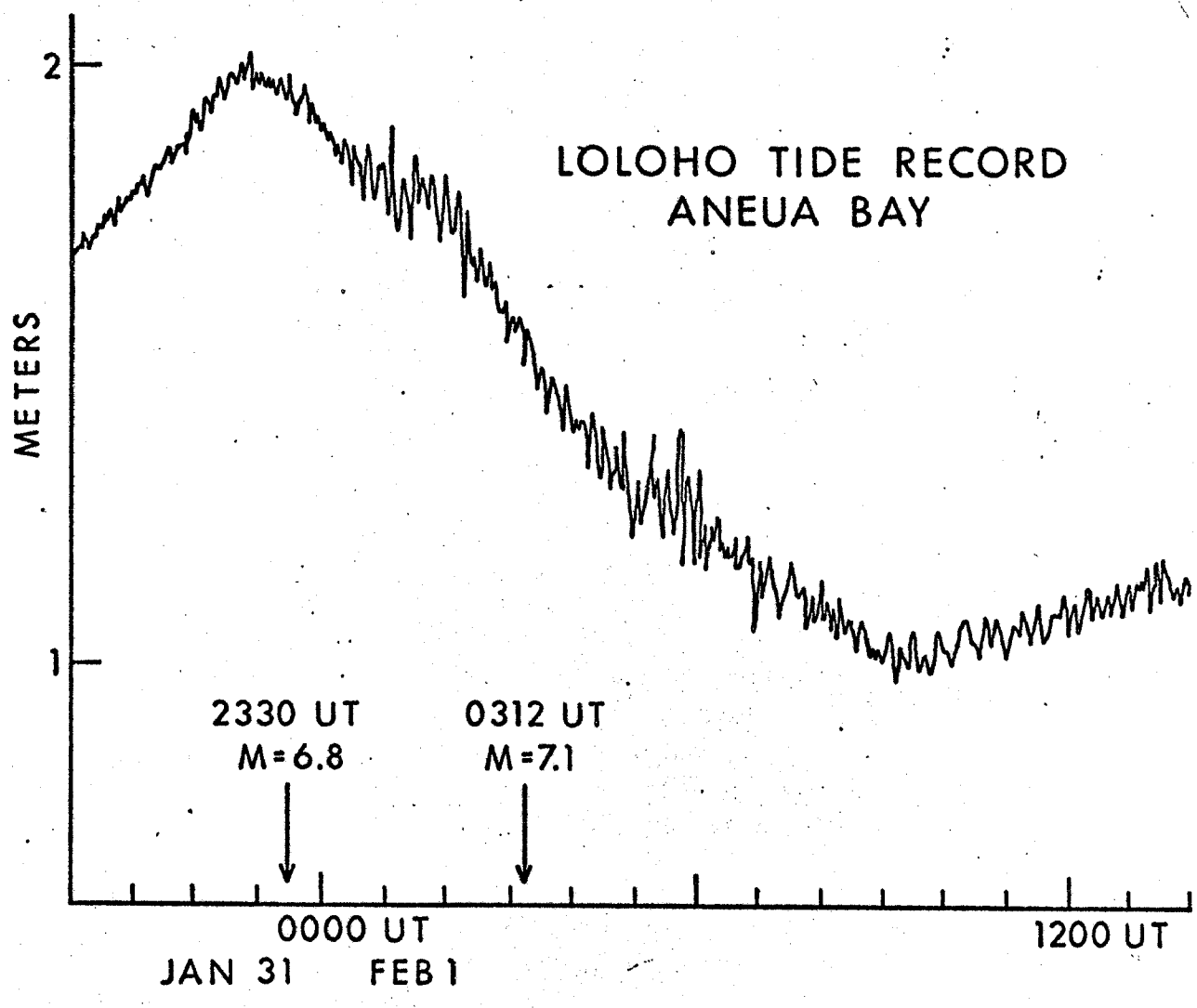
A very limited supply of the last three issues is available upon request.

TSUNAMIS IN SOLOMON ISLANDS

Two earthquakes on January 31 and February 1, 1974 centered near Bougainville Island in the Solomon Islands generated tsunamis which caused minor damage but no casualties. Damage to wharves, roads and bridges was reported on Choiseul Island and the Shortland Islands. Wave heights at these localities were reported to be 3 to 4½ meters. At Torokina on Bougainville, the sea rose about 1 meter. The Loloho (Anewa Bay) tide gage recorded maximum peak to trough waves of about 15 cm. A portion of this tide record is reproduced below. Preliminary epicentral data for the two earthquakes are as follows:

Date	Origin Time	Epicenter	Focal Depth	Magnitude
Jan. 31, 1974	23-30-05.3 U.T.	7.5S, 155.9E	34 km	7.0
Feb. 1, 1974	03-12-33.1 U.T.	7.4S, 155.6E	40 km	7.1

No tsunami watch or warning was issued by the Pacific Tsunami Warning Center after determination that no Pacific-wide tsunamis had been generated.



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